

Prevalence of *Trichinella spiralis* in Commerical Pork Sausage

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PORK sausage products are a primary source of trichinosis in human beings in the United States. Brandly (1) evaluated the sources of infection for 290 cases of trichinosis reported in 1961, and at least 199 were attributable to pork sausage products. The National Communicable Disease Center (2) similarly evaluated 67 cases of trichinosis reported for 1967 and found pork sausage involved in 22 of 28 cases traceable to specific pork products. An additional 25 cases were attributed to unspecified pork products, many of which may have been of the sausage type. A major outbreak involving 76 confirmed and 16 probable cases of trichinosis in 1969 was traced to summer sausage prepared by a noninspected meat processor in a small midwest city (3).

Only limited studies with varying results have been made to determine the presence of *Trichinella spiralis* in commercial pork sausage products. Dickman (4) detected trichinae in six (9.5 percent) of 63 sausage samples from Philadelphia. Kerr (5) found trichinae in 21 (2.0 percent) of 1,056 fresh pork sausage samples available in California. Peres (6) found no trichinae in 50 samples of sausage from New Orleans. Bair and Etges (7) examined 2,141

grams of link sausage and 1,821 grams of bulk sausage from Cincinnati, Ohio, with negative results.

Any ready-to-eat product containing pork when prepared under Federal or equivalent State meat inspection must be processed to kill trichinae (8). The processing must include heating to a minimum of 137° F., freezing at prescribed time-temperature relationships, or curing by using approved methods.

Schwartz (9) examined 1,118 half-pound samples of federally inspected frankfurters. Eleven contained trichinae, with a maximum of two trichinae per positive sample, but none of the trichinae was considered infective.

Harrington and associates (10) reported two studies which entailed examinations of pork sausage products which had been treated to kill trichinae. During 1934-39, trichinae were found in 433 (3.3 percent) of 13,013 half-pound samples examined. Only four samples contained living trichinae, all of which were judged as being noninfective. In similar studies by Harrington and associates during 1948-49, only 26 (0.82 percent) of 3,171 samples were found to contain trichinae, with 24 containing only dead trichinae. Kerr (5), in California, did not detect any trichinae in 609 samples of sausage which had been treated to kill trichinae.

Since swine are not routinely examined for trichinae in the United States, monitoring samples of pork sausage is one way to determine roughly the distribution of *T. spiralis* in swine and obtain an indication of prevalence trends.

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Studies to determine the prevalence of *T. spiralis* in commercial pork sausage products available in Ames, Iowa, were carried out during 1944-46 and 1953-69. During 1944-46 a prevalence of 12.4 percent was obtained for bulk pork sausage and 11.7 percent for fresh link sausage (11), while a preliminary report of this study indicated prevalences during 1953-60 of only 1 percent for bulk sausage and 2.4 percent for fresh link sausage (12). The study has been terminated and the final results are reported in this paper.

Materials and Methods

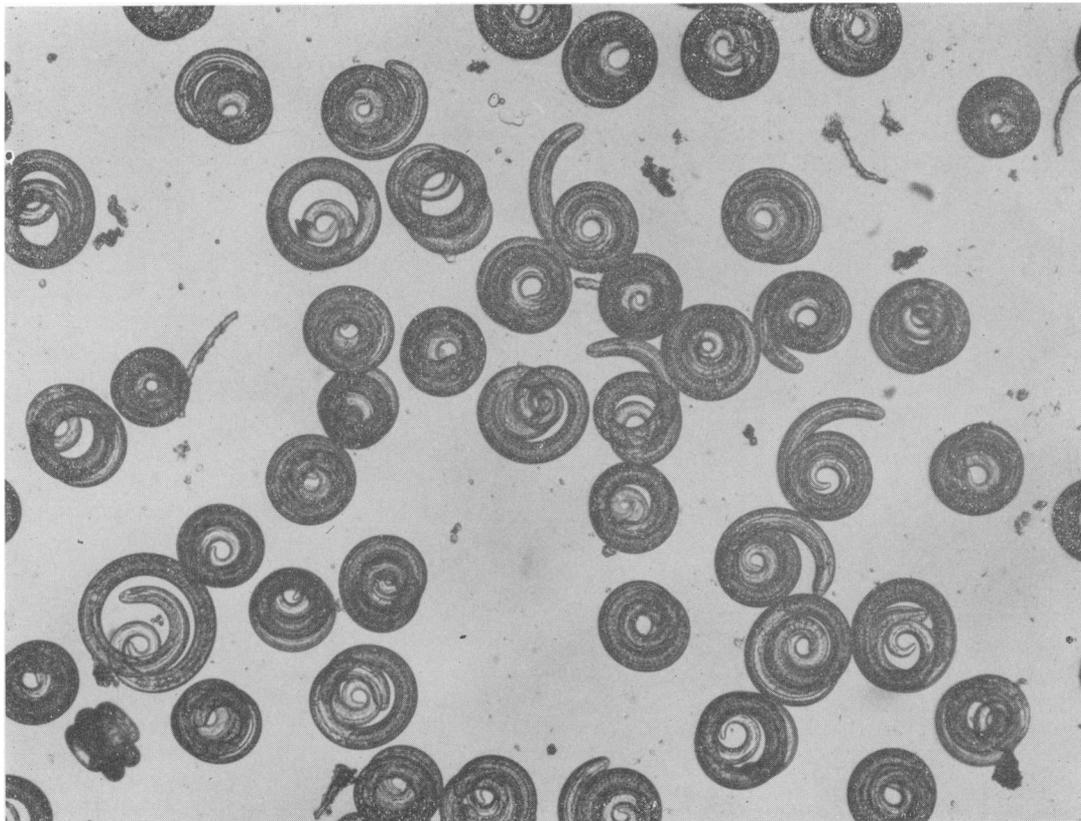
During the 17 years of this study, 1953-69, examinations were made of 12,683 samples of fresh bulk sausage, 2,568 samples of fresh link

sausage, and 3,366 samples of treated link pork sausage which had been processed by curing, heating, or freezing to render trichinae noninfective. All samples were bought from retail stores.

Sausage products from 35 processors were examined in this study (table 1). Brands 1-4 were sold under the labels of local meat retailers. All bulk sausage listed under these brands was made in the individual stores. The link sausages for these brands were prepared by other processors but sold under the store's label. Brands 5-8 were made under local inspection during the first part of the study but are now made under Federal inspection. All other brands examined in the study were made in federally inspected packinghouses.

Table 1. Distribution of positive samples of pork sausage, by brands

| Brand | Bulk | | | Link | | | Treated | | |
|------------|-----------------|-----------------|------------------|-----------------|-----------------|------------------|-----------------|-----------------|------------------|
| | Number examined | Number positive | Percent positive | Number examined | Number positive | Percent positive | Number examined | Number positive | Percent positive |
| 1..... | 7,011 | 56 | 0.8 | 588 | 9 | 1.5 | 102 | 0 | 0 |
| 2..... | 168 | 0 | ----- | 22 | 0 | ----- | 0 | 0 | ----- |
| 3..... | 235 | 1 | .4 | 14 | 0 | ----- | 0 | 0 | ----- |
| 4..... | 203 | 0 | ----- | 2 | 0 | ----- | 189 | 0 | ----- |
| 5..... | 0 | 0 | ----- | 73 | 0 | ----- | 38 | 1 | 2.6 |
| 6..... | 0 | 0 | ----- | 22 | 0 | ----- | 0 | 0 | ----- |
| 7..... | 439 | 4 | .9 | 69 | 0 | ----- | 47 | 0 | ----- |
| 8..... | 216 | 0 | ----- | 0 | 0 | ----- | 15 | 1 | 6.7 |
| 9..... | 494 | 10 | 2 | 42 | 0 | ----- | 30 | 0 | ----- |
| 10..... | 0 | 0 | ----- | 0 | 0 | ----- | 1 | 0 | ----- |
| 11..... | 0 | 0 | ----- | 37 | 0 | ----- | 35 | 0 | ----- |
| 12..... | 22 | 0 | ----- | 4 | 0 | ----- | 50 | 0 | ----- |
| 13..... | 561 | 3 | .5 | 528 | 3 | .6 | 1,083 | 1 | .09 |
| 14..... | 206 | 2 | 1 | 91 | 0 | ----- | 0 | 0 | ----- |
| 15..... | 7 | 0 | ----- | 401 | 1 | .2 | 759 | 1 | .1 |
| 16..... | 246 | 2 | .8 | 84 | 2 | 2.4 | 81 | 2 | 2.5 |
| 17..... | 610 | 4 | .7 | 172 | 0 | ----- | 332 | 0 | ----- |
| 18..... | 602 | 13 | 2.2 | 333 | 15 | 4.5 | 517 | 1 | .2 |
| 19..... | 12 | 0 | ----- | 10 | 0 | ----- | 0 | 0 | ----- |
| 20..... | 25 | 2 | 8 | 62 | 12 | 19.4 | 25 | 0 | ----- |
| 21..... | 10 | 0 | ----- | 3 | 0 | ----- | 12 | 0 | ----- |
| 22..... | 386 | 0 | ----- | 0 | 0 | ----- | 0 | 0 | ----- |
| 23..... | 1 | 0 | ----- | 0 | 0 | ----- | 1 | 0 | ----- |
| 24..... | 17 | 0 | ----- | 0 | 0 | ----- | 0 | 0 | ----- |
| 25..... | 613 | 9 | 1.5 | 11 | 1 | 9.1 | 29 | 0 | ----- |
| 26..... | 519 | 2 | .4 | 0 | 0 | ----- | 0 | 0 | ----- |
| 27..... | 60 | 0 | ----- | 0 | 0 | ----- | 0 | 0 | ----- |
| 28..... | 5 | 1 | 20 | 0 | 0 | ----- | 0 | 0 | ----- |
| 29..... | 15 | 0 | ----- | 0 | 0 | ----- | 0 | 0 | ----- |
| 30..... | 0 | 0 | ----- | 0 | 0 | ----- | 14 | 0 | ----- |
| 31..... | 0 | 0 | ----- | 0 | 0 | ----- | 1 | 0 | ----- |
| 32..... | 0 | 0 | ----- | 0 | 0 | ----- | 1 | 0 | ----- |
| 33..... | 0 | 0 | ----- | 0 | 0 | ----- | 2 | 0 | ----- |
| 34..... | 0 | 0 | ----- | 0 | 0 | ----- | 1 | 0 | ----- |
| 35..... | 0 | 0 | ----- | 0 | 0 | ----- | 1 | 0 | ----- |
| Total..... | 12,683 | 109 | 0.9 | 2,568 | 43 | 1.7 | 3,366 | 7 | 0.2 |



Trichina larvae freed from muscle by digestive process in pork

(Magnified approximately 60 times)

I estimated that about 75-80 percent of the sausage samples originated from Iowa meat processors, with all but a small portion of the remaining samples originating from plants in States bordering Iowa. Forty-five gram samples were routinely used for examination, which was made by the artificial digestion-Baermann technique described in another paper (12).

Results

The prevalence of *T. spiralis* in commercial pork sausage available in Ames, Iowa, is shown in table 2. During the 17 years, 12,683 samples of fresh bulk pork sausage were examined, and 109 (0.9 percent) of these contained trichinae. The prevalence of trichinae in fresh link pork sausage was nearly double that for bulk sausage, with 43 (1.7 percent) of 2,568 samples containing trichinae. No positive sample of bulk sausage was detected during the last 32 months of the study, and no positive sample of link sau-

sage was detected during the last 41 months of the study.

A much lower prevalence of trichinae was noted in treated link sausage which had been processed to destroy or devitalize the parasite. Trichinae were recovered from only seven (0.2 percent) of 3,366 samples of this type of link sausage examined. In contrast to the findings for bulk and fresh link sausage, in which nearly all trichinae were alive, only one of the seven positive samples contained living trichinae. Thirteen of the 20 larvae recovered from this sample were dead, with the other seven appearing to be devitalized. However, no test for viability was made by feeding the trichinae to rats.

A downward trend in prevalence of trichinae was noted throughout much of the study. This is shown in table 3, where studies during 1944-46 (11) are compared with those obtained from this study, which was arbitrarily divided into three periods. A markedly decreasing rate of

Table 2. Prevalence of *T. spiralis* in samples of pork sausage, by years

| Year | Bulk | | | Link | | | Treated | | |
|----------------------|-----------------|-----------------|------------------|-----------------|-----------------|------------------|-----------------|-----------------|------------------|
| | Number examined | Number positive | Percent positive | Number examined | Number positive | Percent positive | Number examined | Number positive | Percent positive |
| 1944-46 ¹ | 460 | 57 | 12.4 | 444 | 52 | 11.7 | | | |
| 1953 | 44 | 1 | 2.3 | 40 | 2 | 5.0 | 11 | 0 | |
| 1954 | 726 | 13 | 1.8 | 341 | 6 | 1.8 | 368 | 0 | |
| 1955 | 899 | 8 | .9 | 282 | 13 | 4.6 | 348 | 0 | |
| 1956 | 1,245 | 30 | 2.4 | 228 | 6 | 2.6 | 1 | 0 | |
| 1957 | 1,395 | 3 | .2 | 243 | 2 | .8 | 35 | 0 | |
| 1958 | 1,397 | 21 | 1.5 | 108 | 2 | 1.9 | 63 | 2 | 3.2 |
| 1959 | 1,774 | 9 | .5 | 107 | 1 | .9 | 9 | 0 | |
| 1960 | 1,953 | 7 | .4 | 162 | 3 | 1.9 | 52 | 0 | |
| 1961 | 988 | 13 | 1.3 | 269 | 6 | 2.2 | 34 | 0 | |
| 1962 | 354 | 2 | .6 | 195 | 0 | | 275 | 2 | .7 |
| 1963 | 365 | 0 | | 102 | 0 | | 321 | 0 | |
| 1964 | 274 | 0 | | 87 | 0 | | 296 | 0 | |
| 1965 | 189 | 0 | | 46 | 1 | 2.2 | 165 | 1 | .6 |
| 1966 | 277 | 1 | .4 | 72 | 1 | 1.4 | 228 | 2 | .9 |
| 1967 | 240 | 1 | .4 | 101 | 0 | | 353 | 0 | |
| 1968 | 281 | 0 | | 89 | 0 | | 431 | 0 | |
| 1969 | 282 | 0 | | 96 | 0 | | 376 | 0 | |
| Total | 12,683 | 109 | .9 | 2,568 | 43 | 1.7 | 3,366 | 7 | .2 |
| Grand total | 18,617 | 159 | | | | | | | |

¹ Reference 11.

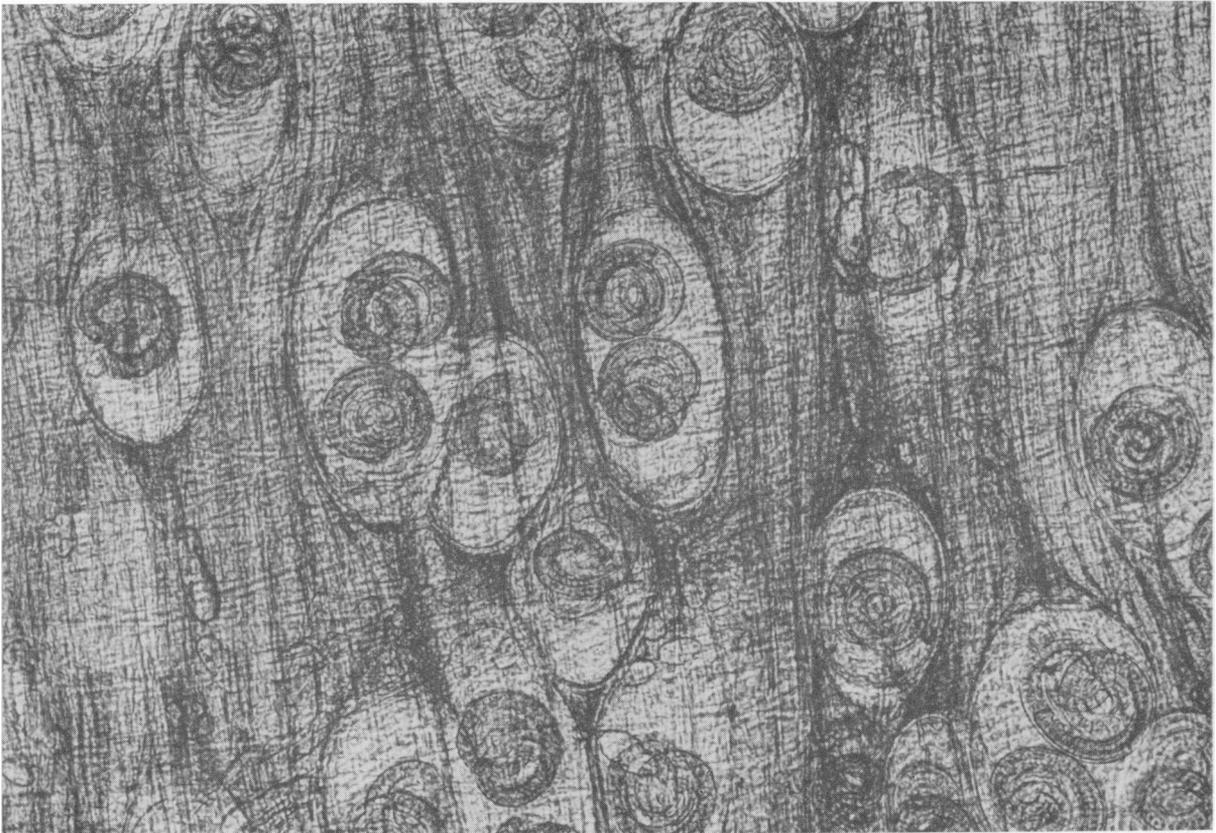
Table 3. Prevalence of *T. spiralis* in samples of pork sausage, by selected periods

| Period (years) | Bulk | | | | Link | | | |
|----------------------|-----------------|-----------------|------------------|-------|-----------------|-----------------|------------------|-------|
| | Number examined | Number positive | Percent positive | Rate | Number examined | Number positive | Percent positive | Rate |
| 1944-46 ¹ | 460 | 57 | 12.4 | 1:8 | 444 | 52 | 11.7 | 1:9 |
| 1953-58 | 5,706 | 76 | 1.3 | 1:75 | 1,242 | 31 | 2.5 | 1:40 |
| 1959-64 | 5,708 | 31 | .54 | 1:184 | 922 | 10 | 1.1 | 1:92 |
| 1965-69 | 1,269 | 2 | .16 | 1:635 | 404 | 2 | .50 | 1:202 |

¹ Reference 11.

Table 4. Concentration of *T. spiralis* in positive samples of pork sausage

| Trichinae per gram | Bulk | | Link | | Treated | |
|--------------------|-----------------|------------------|-----------------|------------------|-----------------|------------------|
| | Number examined | Percent positive | Number examined | Percent positive | Number examined | Percent positive |
| 0.1 or less | 77 | 70.6 | 26 | 60.5 | 3 | 42.9 |
| 0.11-0.30 | 20 | 18.3 | 10 | 23.3 | 3 | 42.9 |
| 0.31-0.50 | 4 | 3.7 | 2 | 4.7 | 1 | 14.3 |
| 0.51-1.00 | 1 | .9 | 2 | 4.7 | | |
| More than 1.00 | 7 | 6.4 | 3 | 7 | | |
| Total | 109 | 99.9 | 43 | 100.2 | 7 | 100.1 |



Trichina larvae encysted in a rat diaphragm

(Magnified approximately 60 times)

prevalance of trichinae in both bulk and fresh link pork sausages was noted between successive periods throughout the study.

The concentration of trichinae in the positive sausage samples is shown in table 4. Seventy-seven (70.6 percent) of the positive bulk samples contained 0.1 or less larvae per gram, while an additional 20 (18.3 percent) contained only 0.11–0.30 trichinae per gram. Only seven (6.4 percent) of the 109 positive bulk sausage samples contained more than one parasite per gram, with a maximum of 7.1.

A somewhat similar distribution was noted for positive fresh link samples as 60.5 percent contained 0.10 or less trichinae per gram, 23.3 percent contained 0.11–0.30 per gram, while only 7 percent contained more than one trichina per gram. The maximum was 5.4.

Positive bulk samples were found among 13 of the 25 brands of bulk sausage, seven of 20 brands of fresh link sausage, and six of 24

brands of treated sausage (table 1). High prevalences were obtained for brand 20 (bulk, 8.0 percent, fresh link, 19.4 percent); brand 18 (bulk, 2.2 percent, fresh link, 4.5 percent); and brand 25 (bulk, 1.5 percent, fresh link, 9.1 percent).

Other brands of bulk sausage having prevalences of trichinae of 1 percent or more included brand 9, 2.0 percent; brand 14, 1.0 percent; and brand 28, 20.0 percent. However, only five samples of brand 28 were examined.

For fresh link sausage, brand 1 had a prevalence of 1.5 percent and brand 16, 2.3 percent. Three brands of treated link sausage had high prevalences of trichinae: brand 5, 2.6 percent; brand 8, 6.7 percent; and brand 16, 2.5 percent.

The relatively high prevalences of trichinae in brands 5, 8, 9, 14, 16, 18, 20, 25, and 28 were related primarily to the high rate of prevalence obtained in the initial half of the study. Nearly all of the positive samples for these brands were

found before 1962. All positive samples for brand 20 link sausage were found during 1954–55, while both positive samples of brand 20 bulk sausage were detected during the 1956–58 period. All positive samples of brand 18, both bulk and fresh link, were obtained before 1962, with nearly three-fourths found during the 1953–58 period. Similarly, positive samples of most of the brands of sausage with a high prevalence of trichinae were detected before 1962.

These relatively high prevalences of trichinae would also reflect on the source of the swine. Five of the seven bulk samples containing more than one trichina per gram were found in brands 1 and 3, made by local meat retailers.

Twenty-two positive samples were obtained in both April and August, while 20 were found in June. The greatest hazard to the health of the consumer occurred during the period of March through August, when 109 of the 159 positive samples were detected.

Discussion

There is increasing evidence that trichinosis is decreasing markedly as a public health problem in the United States. Wright and co-workers (13) obtained a prevalence of 16.1 percent from 5,313 human diaphragms examined during 1936–41, while Zimmermann and associates (14) reported a prevalence of only 4.2 percent for 5,000 human diaphragms examined during 1966–68.

A similar sharp reduction in trichinosis has also been noted in swine. The prevalence in farm-raised (primarily grain-fed) swine decreased from 0.95 percent in the 1930's (15) to only 0.12 percent in butcher weight and 0.22 percent in breeder swine during 1961–65 (16). The prevalence in garbage-fed swine decreased from 11 percent in 1950 (15) to only 0.5 percent in 1964–66 (17).

Similar declines have been noted in Iowa in the prevalence of the parasite. Wright and co-authors (13), during 1936–41, obtained a prevalence of 16.2 percent in human beings in Iowa while Zimmermann (18) reported a prevalence of 2.8 percent in man during 1961–65. Zimmermann and co-workers (19) reported a prevalence of 0.17 percent in Iowa swine examined during 1953–57 while in various studies since 1961, I

found only one (0.017 percent) infected Iowa swine among approximately 6,000 examined.

This study on the prevalence of *T. spiralis* in pork sausage reveals further evidence that the problem is decreasing. In 25 years the prevalence of trichinae in fresh bulk sausage commercially available in Ames, Iowa, had decreased from a rate of one positive sample for each eight examined (12.5 percent) during 1944–46 to only one trichina-containing sample for each 635 samples examined (0.16 percent) during 1965–69. This decline has been continuous as indicated by the rates obtained for the intervening periods.

A similar downward trend has been noted for fresh link sausage. The prevalence rate decreased from one positive per nine samples examined (11.7 percent) in 1944–46 to one per 202 samples (0.5 percent) during 1965–69. The declining prevalences of trichinae in Iowa swine and sausage products are especially significant since nearly one-fourth of U.S. swine are raised in Iowa.

The prevalence rate of trichinae in fresh link sausage was basically double that in bulk sausage throughout the 17 years of this study. This difference was not noted during the 1944–46 study. The reason for this difference is not readily apparent. A limited number of analyses on the fat content of both bulk and link sausage revealed no marked differences. It is possible that some packers may use swine diaphragm trimmings more commonly for link than for bulk sausage. The diaphragm generally has a concentration of trichinae ranging from two to seven times higher than other pork cuts (20).

In studies of trichinosis in swine, only those infections containing one or more trichinae per gram are considered significant (15), that is, capable of causing clinical trichinosis in man. If this criterion is also applied to sausage, seven bulk and three fresh link sausage samples were in this category. These samples were only 0.06 percent of the total bulk and 0.12 percent of the total link sausage examined. All but three of the 10 samples containing more than one trichina per gram were detected prior to 1960. The last three were found in October 1960, April 1961, and September 1966.

As implied earlier, most sausage is made from pork trimmings. The sausage produced by major

meatpackers is made from the trimmings of many swine. Thus trichinae are diluted throughout a large number of sausage samples, giving a higher prevalence rate than obtained for swine but a lower concentration of trichinae because of this dilution.

The effect of the dilution on prevalence of trichinae can be shown by comparing the prevalence for sausage with that obtained for swine. During 1953-57, 1.33 percent of bulk sausage samples contained trichinae while only 0.16 percent of Iowa swine were infected. While the prevalence of trichinae in bulk sausage declined to 0.16 percent in 1965-69, that for swine decreased to 0.017 in 1961-69. Thus because of this dilution, the prevalence in commercial bulk sausage is eight to 10 times that obtained for individual swine.

Differences were also noted in bulk sausage produced by slaughterhouses and that produced by retail markets. Sausage made in retail markets would generally be made from fewer pigs. Thus the prevalence of trichinae would be lower, but the trichinae counts would be higher.

This observation was also confirmed by the results of this study. The 7,617 bulk sausage samples (brands 1-4) prepared by retail markets had a prevalence of 0.75 percent in contrast to the prevalence of 1.03 percent for the 5,066 samples prepared by meatpackers. Concentration of trichinae was higher, however, in the sausage produced in retail markets because five of the seven bulk samples containing one or more trichinae per gram were market made.

This problem is even more important in home or locally slaughtered swine because sausage is generally prepared from a single pig. Trichinae, if present, would not be diluted, and a major health hazard would be present if the sausage was not properly prepared prior to human consumption. Thus outbreaks of trichinosis from sausage prepared at packinghouses would probably involve more people because of the dilution factor, but the intensity of infection would be less than that obtained from sausage prepared with pork from one or a limited number of swine.

Sausage generally considered ready-to-eat must be processed in packinghouses to kill trichinae prior to marketing only when prepared in federally inspected plants or in those State-

inspected plants operating under Federal regulations. The Wholesome Meat Act, enacted in December 1967 as an amendment to the Federal Meat Inspection Act, markedly increased the number of establishments operating under these regulations.

Ready-to-eat sausage includes most smoked sausages, pepperoni, summer sausage, salami, polish sausage, brown and serve sausages, and similar products. The consumer is assured that the products of this type are free from viable trichinae only when the inspection seal is on the package. Similar products not having this seal, or products not considered ready-to-eat even when an inspection seal is present, must be properly cooked, frozen, or cured before human consumption.

The effectiveness of these regulations is demonstrated by the findings for treated link sausage. The overall prevalence of trichinae in treated link sausage was 0.2 percent, as compared with 1.7 percent for fresh link sausage. Six of the seven positive samples in this category contained only dead trichinae, the seventh contained 20 trichinae, 13 of which were dead and the other seven appearing to be devitalized.

The decline in prevalence of *T. spiralis* in sausage products, along with the increasing availability of ready-to-eat products, would indicate that the hazard of trichinosis is minimal. This is only partially true. Reported cases of trichinosis in human beings have decreased markedly as has the prevalence of the parasite in man and swine. However, major outbreaks, such as the one involving 76 confirmed cases and 16 probable cases which occurred in 1969, will occur sporadically until the parasite is eradicated from U.S. swine.

Major outbreaks nearly always can be traced to ready-to-eat type sausage prepared in noninspected facilities. Two such outbreaks occurred in Iowa during the past decade; one involved 18 persons in 1961 and the other 29 persons in 1966. In both outbreaks, smoked sausages were prepared from federally inspected pork which was not treated to kill trichinae because it was not designated for a ready-to-eat type product. Routine inspection of pork, such as practiced in many countries of the world, followed by freezing or cooking the infected carcasses, would have prevented these outbreaks.

Summary

The prevalence of *Trichinella spiralis* larvae in commercial pork sausage available in Ames, Iowa, was investigated during 1953-69. Studies during 1944-46 had revealed a prevalence of 12.5 percent in bulk pork sausage and 11.7 percent in fresh link pork sausage.

In this study, trichinae were found in 0.9 percent of 12,683 bulk sausage samples, 1.7 percent of 2,568 fresh link sausage samples, and 0.2 percent of 3,366 treated link sausage samples which had been processed to kill trichinae. During the 1965-69 period, only 0.16 percent of 1,269 bulk sausage samples and 0.50 percent of 404 fresh link sausage samples were found to contain trichinae.

No trichinae were detected in bulk sausage during the last 32 months of the study, and in the last 41 months of the study none was found in link sausage. While dead larvae were detected only occasionally in bulk and fresh link sausage, dead larvae only were found in six of the seven positive link samples which had been treated. The seventh contained 20 larvae, of which 13 were dead and the remainder were judged noninfective.

More than 93 percent of the positive samples contained less than one larva per gram. The positive sausages represented 13 brands of bulk, seven brands of fresh link, and six brands of treated link.

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Tearsheet Requests

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